Tailoring an Information Flow Model to Trainee Level of Proficiency

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ABSTRACT: U.S. Army units equipped with emerging networked command and control systems, like all organizations, must channel, manage, assess, and exploit information and requests. The building block relationships among these skills (e.g., channeling facilitates management) relates directly to the crawl-walk-run approach to training. At lower levels of proficiency in applying networked systems, more effort should be spent on information channeling and management, while assessment and exploitation become the foci at higher levels of proficiency. The after action review (AAR) process whereby organizations decide what happened, why it happened, and how to improve or sustain future performance is likely to be a key feedback mechanism for training units to employ networked systems. AARs can be facilitated by the use of aids depicting key exercise events with the goal of increasing awareness and understanding of these events. This paper describes the types of AAR aids relevant to diagnosing problems in information channeling, management, assessment, and exploitation, respectively. The paper also describes how levels of network proficiency impact the need for AAR aids.

1. After Action Review

The after action review (AAR) is the U.S. Army's major method for providing feedback to units after collective exercises [1]. The AAR is an interactive discussion conducted to help units decide what happened, why it happened, and how to improve or sustain future performance. The AAR draws upon the memories of exercise participants as a major source of input. The AAR process can be expedited through the application of aids illustrating critical outcomes or events. AAR aids can help overcome the "fog of war" whereby the intense activity in an actual or simulated combat situation can distort memories of the sequence, timing, and duration of events [2]. AAR aids and the sharing of information among unit members can combine to provide units with a greater awareness and understanding of exercise events by clarifying outcomes and/or causes (e.g., a unit was not in position in time to provide supporting fire).

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) has a long history in terms of research/development conducted to support the application of AAR process across changes in training environments and operational systems [3]. Some of the more recent work focuses on feedback challenges associated with networked command and control (C2) systems that are continually evolving and add substantially to the variety of topics to be addressed by feedback sessions.

This paper describes:

- a high level architecture for measuring organizational proficiency in applying networked systems that is likely to remain valid as the systems evolve
- the relevance of the architecture to AAR aid production
- the impacts of unit proficiency in applying networked systems on AAR aid requirements

2. High Level Measurement Architecture

ARI identified strengths and weakness in applying networked systems that are appropriate as topics for collective feedback sessions and provided guidance to trainers about how to address these topics during AARs [4,5,6]. This work was updated multiple times to

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14. ABSTRACT

U.S. Army units equipped with emerging networked command and control systems, like all organizations, must channel, manage, assess, and exploit information and requests. The building block relationships among these skills (e.g., channeling facilitates management) relates directly to the crawl-walk-run approach to training. At lower levels of proficiency in applying networked systems, more effort should be spent on information channeling and management, while assessment and exploitation become the foci at higher levels of proficiency. The after action review (AAR) process whereby organizations decide what happened, why it happened, and how to improve or sustain future performance is likely to be a key feedback mechanism for training units to employ networked systems. AARs can be facilitated by the use of aids depicting key exercise events with the goal of increasing awareness and understanding of these events. This paper describes the types of AAR aids relevant to diagnosing problems in information channeling, management, assessment, and exploitation, respectively. The paper also describes how levels of network proficiency impact the need for AAR aids.

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reflect changes in networked C2 systems [7]. A high level architecture was created and refined using a bottom-up approach that employed the hundreds of measures of unit network proficiency identified in preparing AAR guidance. The approach involved organizing measures according to the goals supported and then, in turn, organizing these goals according to the higher level goals they support. For example, one measure of network proficiency is whether units take the initiative to insert icons showing the location of non-networked, dismounted forces into situational awareness (SA) displays. The goal addressed by this action is to make sure SA displays accurately depict the location of friendly forces. Having the crew of a network-enabled platform to perform a procedure called a "netjoin" so that the platform's location will be included in SA displays is another of many measures that support this same goal. In turn, this goal supports the higher level goal of assessing and improving upon the accuracy, currency, and completeness of information on the tactical situation. Specific measures may change is systems evolve, but higher level goals are not expected to change.

The resulting architecture includes four information handling activities as the highest level goals. The first goal is to *channel* information so that it flows to the appropriate decision makers. The second is to *manage* information by ensuring it is easy to produce, easy to find, and catches the attention of intended recipients. The third is to *assess* and improve upon the clarity, accuracy, currency, and completeness of information. The fourth is to *exploit* information by using it to make a beneficial decision. Table 1 provides examples of higher levels goals supporting each of the four information processing goals for a network enabled force.

Table 1. Information Processing Skills and Supporting Goals for a Network-enabled Force

Skill	Supporting Goals
Channel Information	▪ Consider terrain impacts on placement of communication assets and communication capabilities ▪ Ensure entities communicate and receive data on friendly locations ▪ Check routing of messages ▪ Use time-saving methods to establish and monitor communication links and diagnose problems ▪ Perform follow-up connectivity checks ▪ Diagnose connectivity problems at lowest feasible level to minimize downtime and maintain a common operating picture ▪ Bridge gaps between different digital systems ▪ Exchange planning products with non-digitized forces ▪ Maintain security of the common operating picture ▪ Maintain backups of critical data ▪ Minimize negative impacts of tactical operations center movement
Manage Information	▪ Make sure recipients receive and/or attend to important messages ▪ Ensure leaders know where to look for information ▪ Avoid confusion over versions of planning products ▪ Delegate responsibility for monitoring digital information ▪ Use automated alerts to reduce monitoring requirements ▪ Make information from external sources available to decision makers ▪ Ensure a common operating picture ▪ Filter and fuse information for decision makers
Assess Information:	▪ Accurately depict the friendly situation ▪ Feed the threat picture ▪ Display and interpret the threat picture ▪ Control views of threat situations ▪ Refine and update planning products ▪ Monitor critical intelligence requirements
Exploit Information	▪ Avoid or prepare for threat situations ▪ Avoid fratricides ▪ Navigate and select routes ▪ Control movement ▪ Predict contact variables ▪ Support during and post-mission reviews of unit performance

In reference to the long term value of the high level architecture, it is important to point out that military organizations channeled, managed, assessed, and exploited information long before networked systems were envisioned. Further, it would be difficult to find any vocation or avocation employing information where these skills are not applied. For example, Table 2 shows some of the ways information channeling, management, assessment, and exploitation apply to investing.

Table 2. Information Processing Skills and Supporting Goals for an Investor.

Skills	Supporting Goals
Channeling	• Establish account with brokerage • Set up on-line account for making transactions • Reduce possibilities that someone will gain access to your accounts • Implement access to information on tax laws impacting investments • Subscribe to investment periodicals
Managing	• Sign up to receive alerts regarding stocks of interest. • Identify web sites or periodicals that consolidate and fuse information • Sign up to have one or more daily market summaries emailed to you
Assessing	• Ensure information on company earnings is current • Ensure positive or negative news on company is current • Ensure information on tax laws is current • Identify key unknowns regarding a potential investment • Decide impact of life events on investment objectives • Decide impact of overall market trends on value of investments
Exploiting	• Receive high return on investments • Reduce tax bite on gains and dividends • Avoid purchase of stocks with major downside potential • Increase income from dividends

3. AAR Aids as a Function of Information Processing and Application Skills

Exploitation of information is the bottom line of unit performance. Problems exploiting information may be due to poor channeling, management, and/or assessment of information, or they may be due to a failure to act upon quality information. AAR aids can document or illustrate poor exploitation and they can help diagnose the causes.

3.1 Information Exploitation and AAR Systems.

The automated or manual systems that produce AAR aids typically address exploitation of information. Many of these aids are produced using simulation data streams describing engagement outcomes, fire control and distribution, movement of forces, and positioning of forces. Some of these AAR aids can be produced using network data streams (e.g., an aid demonstrating that a unit violated a boundary). As networks systems evolve to enable more frequent transmissions of position updates and greater application of sensors, the capability of these systems to provide AAR aids illustrating unit exploitation of information will increase.

There is a difference in perspective between a battle staff and maneuver unit that is important in defining exploitation of information. A battle staff can exploit information by fusing it to produce information displays that provide increased situational understanding. From a unit perspective, this information is not actually exploited until it impacts the commander's decisions. Many of these products are likely to make good AAR aids because they represent the outcome of staff exploitation activities and a major source of input to the exploitation activities of commanders and small unit leaders.

If a unit saves information from the C2 network that can be used for an AAR, then it is exploiting that information for a training advantage. If a unit uses information from the C2 network to see if its performance is on the right track during a mission (to check its processes), then it is exploiting information for an operational advantage.

3.2 Information Channeling, Management, and Assessment and AAR Systems.

If there are problems in exploiting information, then the AAR session will attempt to identify the causes of the problems. If the problem is not due to a failure to exploit good information, it is likely to be due to poor channeling, managing, and/or assessment of information.

Networked C2 systems present certain challenges by increasing the variety of ways in which information can be communicated. Table 3 shows some of the means available for communication in networked environments and information that might be collected to help identify causes of performance problems. The diagnostic information, much of which might be addressed by AAR aids, encompasses channeling, management, and assessment of information. The variety of communication methods makes it hard to predict where certain information can be found, as well as impacting a trainer's workload by increasing the number and variety of data streams to be observed or monitored. Collaborative planning whereby leaders and staff sections can interact directly in real time is being supported by a growing variety of communication methods. It is relevant to point out that the explosive growth in the variety of communication methods, including collaborative modes, is not unique to the military. It also applies to other domains touched by networking, such as investing.

Table 3. New Data Streams and Diagnostic Information in the Networked C2 Environment

Data Streams	Diagnostic Information
Email	Message received, read and understood? Structured format or free-text messages?
Video Teleconferencing	Who is involved? When are they involved? What information is displayed or otherwise communicated?
Shared files	Where are they maintained? When are they updated? Who looks at these files? Can multiple groups work on the same files at the same time? Publication and subscription capabilities employed?
Situational awareness displays	Receiving icons? Displaying icons? Who is looking at these displays? Are there critical differences among SA displays within a unit?
Chat capabilities	Who is involved? When are they involved? What information is communicated?
Feeds from robotic systems (raw and filtered)	Decision-makers see raw or filtered feeds? Competing activities? Are specific intelligence requirements defined? Feeds integrated with other information in the network data loop?
Keystroke data (User interactions with individual systems)	Data filters employed for sending, receiving, and displaying data? Use analytic tools? Response to alerts?
Simulations used in war gaming and/or rehearsals	Who participates? Objectives? Cover entire mission? Results?

The memories of exercise participants can be a major source of information regarding how information was channeled, managed, and assessed. Networked units appear to be very good at remembering when they referred to networked systems, whether they set various filters and initiated automated alerts, and which analytical tools they employed [4]. This reduces the need for the trainer or an automated AAR system to track and document all communications and user interactions with systems. Questions regarding unit application of networked systems have been included in recent collective training guides for AARs [5].

The most effective use of AAR aids is to reduce the "fog of war" and increase awareness and understanding of exercise events, rather than depicting what a unit already knows to be true. Certain information processing activities are difficult to address by asking questions of exercise participants because they involve too many details. In other cases, individual exercise participants may remember what they did during an exercise, but what is important is the patterns or actions across individuals, and AAR aids can support such comparisons.

The job of preparing AAR aids to help identify problems in channeling information has been simplified by the evolution of C2 systems to provide software that can periodically check connectivity among systems and display the results. These displays have the potential to make good AAR aids by providing information about

when the connectivity tools were employed, the problems found, whether the problems were corrected, and, in certain cases, the diagnosis of the connectivity problems. Other AAR aids might target what units did to understand the impact of terrain on communications and share their findings with others.

Information regarding when various planning products are first made available to various audiences is important in providing feedback to units about how well they manage information. It is also the type of information that cannot be addressed effectively by the memories of exercise participants. The job of deciding when and how various planning products are made available within the network may have been simplified by the implementation of publication and subscriptions capabilities within networked system. Unit use of these capabilities enables AAR aids providing precise information about the dissemination of planning products; however, to the extent that planning products are being distributed by some of the alternative methods previously identified in Table 3, keeping track of the dissemination of products can be a challenging task.

AAR aids for illustrating strengths and weaknesses in information assessment include displays comparing ground truth with situations depicted by SA displays. Aids showing tactically relevant information from sensors that was, or could have been, fed into the assessment process are also important. As the number and variety of sensors increase, the job of capturing tactically relevant information for AAR aids can become very challenging.

Figure 1 illustrates how AAR aids and AAR questions can work together in diagnosing performance problems in a manner that uses AAR aids to tell units what they do not already know. What units know regarding exercise events can vary as a function of the network proficiency level, so that AAR aid requirements differ as a function of proficiency level. This topic is addressed in the next section of this paper.

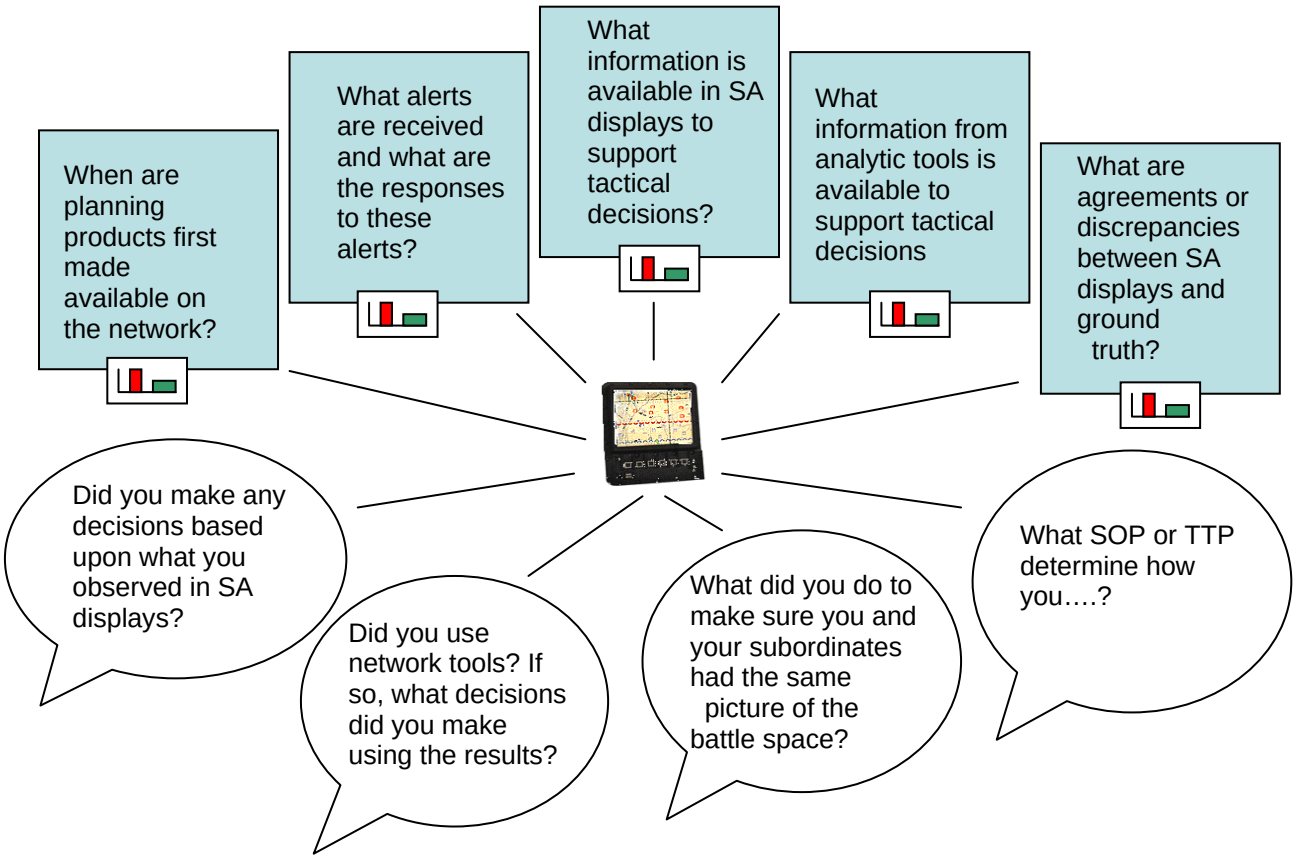

Figure 1. Mixed use of AAR aids and questions to address employment of networked C2 systems

4. Crawl-Walk-Run Approach to Training

A common training strategy is to present students simple instruction at first and then provide successively more complex lessons as they master the material. If the task to be learned is complex, students can easily become overwhelmed if they are expected to learn the entire task at once. Trying to learn too much of a task at once increases mental workload which may interfere with understanding the underlying concepts, and thus interfere with learning [8]. On the other hand, students can lose interest and motivation if lessons are too simple. Therefore, a "crawl-walk-run" strategy allows students to learn successively more complex material as their knowledge and abilities increase. This same strategy applies to collective training for military units.

Figure 2 illustrates the building block nature of the relationships among the four skill groups. Actions taken to meet the goals toward the bottom of the figure set the stage for reaching the goals towards the top of the figure. If an organization has problems channeling information, then information management will be made more difficult due to known and unknown gaps. If an organization has trouble channeling and/or managing information, then it makes it difficult to find the information, let alone assess and improve upon its goodness. Exploiting information is difficult, if it is not flowing to decision-makers, if it is hard to find, or if it is of questionable goodness. At the same time, goals towards the top of the figure motivate and guide the goals towards the bottom.

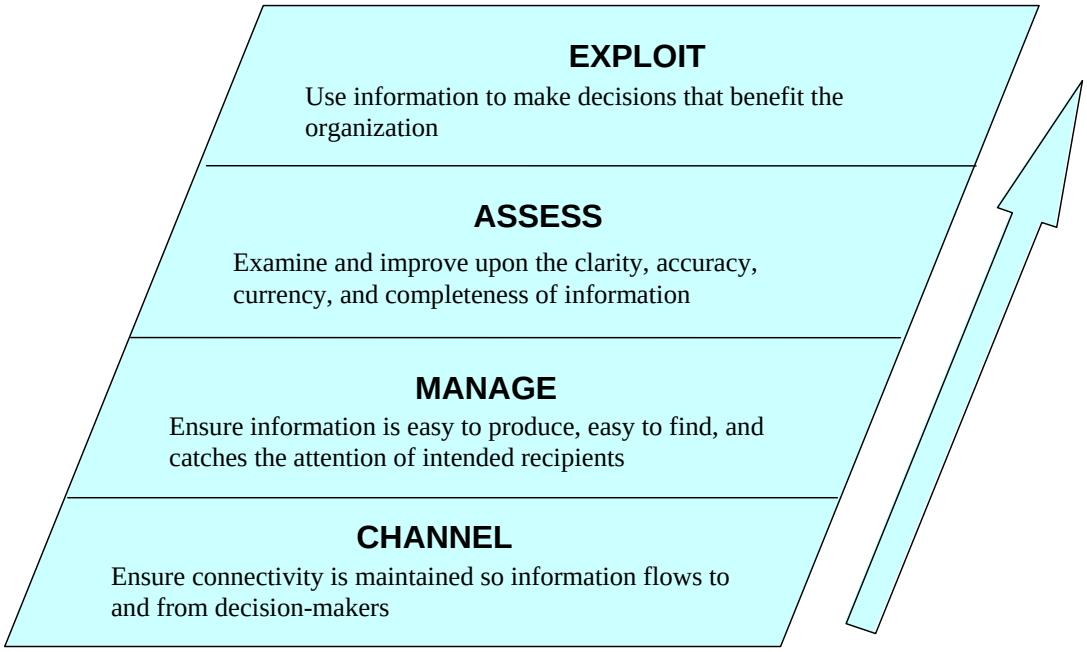

Figure 2 Building block nature of high level information processing and application skills.

A slight modification of the crawl-walk- run approach has been employed for network-enabled units to make sure they experience payoffs (i.e., exploit information) early in training. An effort to apply the crawl-walk-run approach to networked C2 skills training described basic, medium, and high levels of proficiency for Force XXI Battle Command Brigade and Below (FBCB2)-equipped units and battle staffs [6]. Quick Assessment Guides were developed to help leaders estimate a unit's proficiency level. In the case of FBCB2-equipped units the assessment involved asking unit members questions about their Standard Operating Procedures (SOP) for using FBCB2, how they planned on using FBCB2 to plan and execute movement, reduce fratricides, and plan logistical support of operations, what they do to make sure information is current, and what network tasks they practiced in garrison. This effort also provided guidelines for observing units tailored to fit the estimated proficiency level.

At lower levels of proficiency, more of the standards are concerned with channeling and managing information. For higher levels of proficiency more of the standards are concerned with assessing and exploiting information. Each of the four information processing and application skills are represented at each level of unit network proficiency.

At lower levels of unit proficiency there are likely to be few unit SOPs guiding the use of networked systems. For lower proficiency units, the need to develop SOPs will be a major recurring diagnostic theme. Units at higher levels of proficiency, on the other hand, will have SOPs that provide a frame of reference the unit can use to evaluate its own performance.

Units at basic levels of proficiency are concerned with assessing and correcting connectivity problems. At higher levels of proficiency a unit may be more adventuresome and do things to break connectivity and then re-establish it, as when a unit moves a tactical operations center. At more basic levels of proficiency, AAR aids can be used to provide units with feedback regarding how well they maintain connectivity. At higher levels of proficiency, units are likely to be using organic tools to provide their own feedback regarding how well they maintain connectivity. There are also likely to use AAR aids created from their use of these tools for their own feedback purposes.

At more basic levels of network proficiency, FBCB2-equipped units are learning to exploit the network environment by using SA displays, including alerts, to avoid threats, track the location of subordinates during movement, and successfully navigate under limited visibility situations. AAR aids depicting the information available to exploit networked information should be especially useful to these units. Such aids can help motivate units to do all of the work necessary to make sure the SA displays depicted by these AAR aids are actually available, such as effectively disseminating planning products over a network.

At higher levels of network proficiency, units are expected to apply the information channeling and managing skills necessary to produce SA displays describing the threat and networked friendly situation. The training goals for these units include incorporating information about non-networked, joint, and civilian elements into SA displays. It also includes doing a better job of keeping the threat picture current. AAR aids comparing ground truth (i.e., including non-worked, joint, and civilian elements) and SA displays are important for this training audience.

As units move up to medium and high levels of proficiency, they begin to work at higher levels of SA where they have a better idea of how situations will evolve and have a greater understanding of the implications of situations. This higher level of proficiency can be supported, in part, by the use of analytic tools and by creative data fusion and integration products. AAR aids illustrating potential and actual outputs from analytic tools and data fusion products are of value to units at higher network proficiency levels.

Networked systems, especially within a tactical operations center environment, provide a variety of tools that can be used to capture SA displays, tool outputs, and fused data displays throughout a mission for use in providing the commander with a battle update brief. These captures of information also make good AAR aids, and they can also be employed by units as during action reviews to see how well their procedures are working. One would expect only those units at higher levels of network proficiency to employ these information capturing capabilities.

Increases in unit network proficiency can enable trainers to take advantage of an educational technique known as "scaffolding [7]" In "scaffolding," the amount of coaching provided is often considerable at first, and then as the student is able to perform the tasks, coaching is decreased. The term "scaffolding," is a metaphor based on the fact that scaffolding around a building being constructed is removed successively as the building is better able to support itself. In a similar vein, as students are better able to perform tasks without coaching, the coaching is removed. In terms of network skills training, as units become more proficient they have more SOPs, Tactics, Techniques, and Procedures (TTP), self-produced "during action review" aids, and self-produced AAR aids they can use to evaluate their own performance.

To the extent that units begin collective training at higher levels of network proficiency, they can provide the SA displays, analytic tools outputs, and data fusion products that make good AAR aids, reducing or removing the need for the training infrastructure to provide these aids. An important aspect of ARI's efforts to support the training of network-enabled units has been the attempt to focus on diagnosing and correcting performance problems prior to the start of collective training exercises so that these units start collective training at a higher level of proficiency [6].

5. Summary

The AAR process wherein units discuss what happened, why it happened, and how to improve or sustain future performance is the primary method of feedback for U.S.

Army units. AAR aids depicting exercise outcomes and events can expedite the AAR by enhancing the awareness and understanding of exercise events and reducing the "fog of war." The advent of continually evolving networked C2 systems presents challenges to the AAR process that impact the employment of automated systems for preparing AAR aids.

Units channel, manage, assess, and exploit information. Poor unit performance (i.e., inadequate exploitation of information) may be due to poor channeling, management, and/or assessment of information, or it may be due to a failure to act upon quality information. AAR aids based upon simulation data provide information about how well units exploit information. The network data stream is also able to provide selected AAR aids relevant to documenting unit exploitation of information. As networked systems continue to evolve, their data streams will be able to provide an increasing variety of AAR aids documenting unit exploitation of information.

Network data streams can be used to provide AAR aids useful in diagnosing how well units channel, manage, and assess information. The variety of communication methods available to networked units makes it difficult for an automated system to keep track of all key communications. Fortunately the AAR process itself allows for exercise participants to use their recollections of exercise events as input to the AAR, and units appear to be good at remembering many types of networked activities. In general, the most effective use of AAR aids is to tell exercise participants what they do not already know. This type of information includes discrepancies between ground truth and the tactical situations depicted in SA displays, information potentially available from analytic tools to support decisions, and information potentially available from SA displays to support tactical decisions.

The need for the training infrastructure to provide AAR aids is greater for units at lower levels of proficiency. As units become more proficient in applying networked C2 systems, they develop SOPs and TTPs that provide a frame of reference they can use to assess their own performance. They also create their own AAR aids as part of their operations.

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